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METHOD FOR SIMULATING FILM GRAIN BY MOSAICING PRE-COMPUTED SAMPLES

CROSS-REFERENCE TO RELATED APPLICATIONS

5   This application claims priority under 35 U.S.C. 119(e) to U.S. Provisional Patent
Application Serial No. 60/505,146, filed on September 23, 2003, the teachings of which are
incorporated herein.

TECHNICAL FIELD
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          This invention relates to a technique of for simulating film grain in an image.

BACKGROUND ART
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          Prior publications authored by the present inventors and assigned to the present
assignee proposed simulating film grain in a decoded video stream by first filtering grain out
the image before compression. The video stream undergoes compression and subsequent
transmission to a decoder for receipt along with a message containing information about the
20   film grain that was present in the stream prior to compression. Upon receipt of the
compressed video stream and grain-containing message, the decoder decodes the compressed
stream and then restores the original grainy appearance of the image by simulating the film
grain based on the content of the grain information message. The film grain message can take
the form of a Supplemental Enhancement Information (SEI) message accompanying the
25   coded video stream.
          Simulating film grain in this manner provides large bit-rate savings for high quality
applications where the film grain preservation becomes important. However, this method of
simulating film grain increases the decoder complexity since the decoder must reproduce and
blend the film grain with the decoded video stream as specified by the transmitted film grain
30   information message.
          Thus, a need exists for a technique for simulating film grain that overcomes the
disadvantages of the prior art.

BRIEF SUMMARY OF THE INVENTION

Briefly, the present invention provides a method for simulating film grain in an input image block. The method commences by first computing an average value of at least one image parameter for the input image block. Thereafter, a film grain block is selected from at least one previously established pool of film grain blocks whose image parameter most closely matches the image parameter of the input image block. The selected block is then blended with the input image block.

Selecting a film grain block from the at least one pool of pre-established film grain blocks for combination with the input image reduces the complexity associated with simulating the film grain at a decoder as was done by prior methods. Further, selecting a film grain block from the at least one pool of pre-established film grain blocks reduces artifacts that otherwise might arise when transitioning between independently generated film grain blocks.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 depicts the steps of a prior art method for film grain simulation by mosaicing independently generated film grain samples;

FIGURE 2 depicts the steps of a prior art method for generating the film grain blocks for the method of FIG. 1;

FIGURE 3 depicts a part of a prior art decoder for generating a film-grain containing output image;

FIGURE 4 depicts the steps of a method in accordance with an illustrative embodiment of the present principles for simulating film grain by mosaicing pre-computed blocks of film grain;

FIGURE 5 depicts the steps of a method in accordance with an illustrative embodiment of the present principles for pre-establishing the film grain blocks used in the method of FIG. 4; and

FIGURE 6 depicts the steps of a method in accordance with another illustrative embodiment of the present principles for simulating film grain by mosaicing film grain blocks obtained from input image characteristics.

DETAILED DESCRIPTION

In accordance with the present principles, simulation of film grain in an image from occurs by mosaicing pre-established individual film blocks. The term "mosaicing" of the

5 individual film blocks implies the building of a composite image by blending individual film grain blocks that are smaller in size. To appreciate the advantages of film grain simulation by mosaicing pre-established film grain samples, a description of the prior art film grain simulation process will prove helpful.

FIGURE 1 depicts the steps of a prior art method for simulating film grain on a block-

10 by-block basis. The method of FIG. 1 commences by first initializing system variables during step 10.. During step 12, a successive one of a set of blocks of N x M pixels (where N and M are each integers greater than zero) is read from in an input image 13. Reading of the blocks during step 12 occurs in raster-scan order. Prior to step 12, the input image 13 typically undergoes filtering to remove or at least attenuate the film grain followed by decomposition to

15 yield non-overlapping blocks of N x M pixels. Initial compression of the image can itself serve to remove or attenuate film grain. In some instances the input image will not have any initial film grain, either because the image was digitally captured and/or, computer generated. Under such circumstances, adding grain where none existed will enhance the image.

Following step 12, the numeric average of the image intensity, is computed during step

20 14 for the just-read block. Next, film grain parameter selection occurs during step 16. The selection is made from a set of film grain parameters provided in a film grain message 17 accompanying the input image in accordance with the average intensity value computed during step 14. Typically the film grain message 17 takes the form of a Supplemental Enhancement (SEI) Message, and for that reason, the term "SEI message" will appear

25 hereinafter when referring to the message containing film grain information. Because film grain characteristics can vary depending on the intensity level, the selection carried out during step 16 can yield different film grain parameters depending on the average intensity measured on the extracted image block.

Using the film grain parameters selected during step 16, an N x M pixel block of film

30 grain samples is generated during step 18 for use in creating a film grain image 19. Each of the film grain blocks generated through this process undergoes storage and compositing to yield a film grain image that maps to the size of the original input image. This composition process constitutes mosaicing as discussed earlier. Following step 18, a check occurs during

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step 20 whether the block selected during step 12 constitutes the last block of the input image 11. If additional blocks remain, program execution branches to step 12 and those following it. Otherwise, step 22 occurs and the process ends

FIGURE 2 depicts the individual steps that collectively comprise the step 18 of FIG. 1
5   for generating block of N x M film grain samples. The method of FIG. 2 commences upon execution of step 200 during which initialization of system variables occurs. Thereafter, generation of a block of N x M random values occurs during step 202 using one or more parameters obtained from the SEI message 17. The block generated during step 204 undergoes a Discrete Cosine Transformation (DCT) during step 204 to obtain a corresponding
10 set of N x M frequency coefficients. Other transforms, besides DCT could also be used. The coefficients computed during step 204 undergo frequency filtering during step 206, with the filtering coefficients computed in accordance with one or more of the parameters contained in the SEI message 17. The frequency filtering controls the size of the simulated grain. The frequency-filtered coefficients undergo an Inverse Discrete Cosine Transform (IDCT) during
15 step 208 to yield the film grain image 19. This process requires specification of the noise deviation as well as the high and low cut frequencies that control the filtering process in the frequency domain. For video coding applications, the SEI message 17 typically conveys such information. Following step 208, the process ends.

FIGURE 3 depicts a block schematic diagram of a portion of a decoder 300 that
20 accomplishes film grain blending with the original image. A summing block 310 within the decoder 300 receives a decoded input image 13 at a first input. The film grain image 19 of FIG. 2 undergoes deblocking at a de-blocking filter 314 prior to receipt at the second input of the summing block 310. The summing block 310 sums the input image 13 and the film grain image 19 to yield an output image 316 that contains film grain. Since the individual blocks of
25 film grain have been generated independently, artifacts can be perceived at the transitions between blocks. Thus, the de-blocking filter 314 becomes important to reduce the visual artifacts resulting from the film grain mosaicing.

As thus described, the prior art method for film grain simulation requires the generation of film grain for blending with each processed block of pixels of the input image.
30 In contrast, the film grain simulation in accordance with the present principles achieves greater efficiency by limiting the film grain generation by way of a pool creation process in which a limited number of film grain blocks are computed. This approach strongly reduces the computational complexity of the film grain simulation process.

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FIGURE 4 depicts the steps of a method in accordance with a first embodiment of the present principles for film grain simulation. As discussed in greater detail hereinafter, the film grain simulation method of FIG. 5 advantageously avoids film grain generation on the fly by selecting individual pre-computed film grain blocks from a pool of such blocks. The method of FIG. 4 commences by first initializing system variables during step 400. Next a successive block of N x M pixels is read during step 402 from the input image 13. Reading of the blocks during step 402 occurs in raster-scan order. As discussed above, the input image 13 typically will have had all of its grain removed or attenuated and will have been decomposed into non-overlapping blocks of N x M pixels (where N and M are integers each greater than zero). Initial compression of the image can itself serve to remove or attenuate film grain. In some instances the input image will not have any initial film grain, either because the image was digitally captured and/or, computer generated. Under such circumstances, adding grain where none existed will enhance the image.

Following step 402, the average value of an image parameter, typically, the average intensity value is computed during step 404 for the block just read during step 402. Next, a film grain block is selected during step 406 from at least one pool of pre-established film grain blocks pre-computed in the manner described hereinafter with respect to FIG. 5. Rather than rely on a single pool of film grain blocks, multiple pools could exist from which selection could occur dependent on the average image intensity or dependent on one or more other image parameters. When more than one block is available for the same intensity level and color component, a selecting criterion should be specified. For example, pseudo-random selection of blocks from the pool could occur to avoid the creation of patterns when a reduced number of blocks are available. Use can also be made of transformed copies of the set of available film grain blocks.

Following block selection during step 406, the selected block typically undergoes a transform during step 410 to yield the film grain image block 19 for blending with the film grain image.. Following step 410, a check occurs to determine whether additional image blocks remain during step 412. If additional image blocks remain, program execution branches to step 402 and those following it. Otherwise, program execution ends during step 414.

FIGURE 5 illustrates the steps of a method in accordance with the present principles for generating the pre-established film grain blocks 408 of FIG. 4. The method of FIG. 5 commences by first performing initialization during step 500 to reset all system variables.

Next, selection of a set of film grain parameters from the SEI message 17 occurs during step 502. Thereafter, a set of K blocks of film grain samples (where K is an integer greater than zero) is generated for each set of parameters in the SEI message 17 during step 504. Different sets of parameters will specify different color components and different intensity levels. A

5   particular implementation with K=1 results in the lowest computational requirements, generating only one block of film grain per set of parameters. However, to avoid the creation of patterns, it is preferable to use of a larger number of blocks or even a different number of blocks for different intensity levels.

Following step 504, a check occurs during step 506 to determine whether additional

10   parameter sets remain. If additional sets remain, program execution branches to step 502 and those following it. Otherwise, program execution ends during step 508.

The process described with respect to FIG. 5 for creating a pool of pre-established film grain blocks remains completely decoupled from the film grain blending that occurs in the decoder 10 as described in FIG. 3. Despite the computational advantage of anticipating film

15   grain generation, the film grain simulation method of FIG. 4 incurs the inconvenience of remaining unaware whether the input images will make use of all the blocks stored in the pool.

FIG. 6 illustrates an alternative embodiment of a film grain simulation method according to the present principles that makes use of the characteristics of input images. As

20   will become better understood hereinafter, the film grain method of FIG. 6 does not create a pool of film grain blocks a priori for all the possible intensity levels present in the SEI message 17. Instead, the method of FIG. 6 undertakes creation of a limited pool of film grain blocks and undertakes to update of the pool of blocks depending on the input image characteristics.

25   The method of FIG. 6 commences by first performing initialization during step 600 to reset all system variables. Step 602 follows step 600 during which selection of a block of N x M pixels from the input image 13 occurs. Thereafter, the average of at least one image parameter (e.g., the average of the image intensity) of the previously selected image block is computed during step 604. During step 606 a check occurs for the availability of a film grain

30   block whose average intensity most closely matches the average intensity of the selected image block. If no such block exists, then program execution branches to step 608, a set of parameters are selected from the SEI message 17. Next, an N x M film grain block is generated from the selected parameters during step 610. The block generated during step 610

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now enters the pool of pre-computed film grain blocks 408. Step 612 follows step 610. Step

612 also follows step 606 upon a determination that a film grain block in the pool has an

average intensity mostly closely matching that of the selected image block. During step 612,

selection of the most closely matching film grain block occurs from the pool 408 of film grain

5   blocks. Next, the selected block typically undergoes a transform during step 614 for

mosaicing with the previously selected blocks to yield the film grain image 19. In this way,

the transform block is blended with the film grain image. A determination occurs during step

616 whether the block selected during step 602 constitutes the last block. If not, program

execution branches to step 602. Otherwise, program execution ends during step 618.

10   The above-described method can estimate if blocks are not available not only when the

pool 408 is empty, but also if the existing blocks have been recently used for blending. Other

criteria for managing the pool creation and update process could also be envisaged.

The method of FIG. 6 could progressively create and/or update the pool 408 of pre-established

film grain blocks depending on the characteristics of the input images. For example, the pool

15   408 could be organized to arrange a larger number of blocks within the most -prevalent

intensity levels to avoid the creation of visual patterns. According to this strategy, the

distribution of film grain blocks in the pool 408 would progressively match variations in the

image characteristics related to darkening or lightening.

The foregoing describes a technique for simulating film grain in an image.